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Performance and Emission Characteristics of Spark Ignition Engine Fueled with Plastic Petrol Derived from Waste Plastic

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Abstract

The increasing industrialization, urbanization and changes in the pattern of life, which accompany the process of economic growth, give rise to generation of increasing quantities of wastes leading to increased threats to the environment. Environmental degradation and depleting oil reserves are matters of great concern around the globe. Developing countries like India depend heavily on oil import of about 125 Mt per annum. In this context, waste plastic solid is currently receiving renewed interest. Plastics have now become indispensable materials in the modern world and application in the industrial field is continually increasing. As an alternative, non-biodegradable, and renewable fuel, waste plastic oil is receiving increasing attention. Replacement (partial) of fossil fuels with alternate fuels has been set as a target worldwide to reduce greenhouse effect and energy dependence as well as to improve economy. In the present day scenario emissions associated with the exhaust of automobiles resulting in global warming is a major menace to the entire world and also detrimental to health. As the fossil fuels are depleting day by day, there is a need to find out an alternative fuel to fulfill the energy demand of the world. Environmental concern and availability of petroleum fuels have caused interests in the search for alternate fuels for internal combustion engines.An experimental investigation is conducted to evaluate the use of Plastic Petrol derived from waste plastic in a Spark Ignition engine. The tests are conducted using each of the Gasoline and Plastic Petrol with the engine working at Constant speed. Fuel consumption and exhaust regulated gas emissions such as carbon monoxide, carbon dioxide and total unburned hydrocarbons are measured. The differences in the measured performance from the baseline operation of the engine, i.e., when working with Gasoline fuel and the Plastic Petrol are determined and compared. The experimental results show that plastic petrol under study shall conveniently be used as a substitute to gasoline in the existing SI engines without any modifications.

Keywords: *SI engine, Emissions, Combustion, Plastic Petrol and Gasoline.*

1. Introduction

Automobile emissions are increasing day by day and there is catastrophic future in respect of human health degradation. The emission regulatory boards are imposing stringent rules in controlling emissions worldwide. The population of fossil fuel-run vehicles is increasing in multifold every year leading to peak pollution levels. Research round the globe is focused on the ways to reduce regulated and unregulated tail pipe emissions. Regulated emissions like NO_x, HC and CO emissions are important ones to be contained. Therefore, the need for reducing/minimizing emission levels of NO_x, HC, CO etc drawing attention of many a researcher. This can be achieved either by switching over to renewable fuels or by any other method which do not invite major changes in the design aspect of the engine in use which entails additional expenditure.

Rudolph Diesel stipulated as a condition of his rational heat motor that fuel must be introduced gradually so as to maintain an isothermal combustion process [1](Diesel, 1897). The promise of simultaneously reduced NOx and Particulate Matter (PM) offers attractive incentives, especially considering the associated minor penalties in fuel economy.

The popular press has become excited at the prospects of HCCI-type combustion systems, which are viewed as the internal combustion engine's best response to future competition from fuel cells and hybrids [2]. All transport vehicles with SI and CI (compression ignition) engines are equally responsible for the emitting different kinds of pollutants [3]. Some of these are primary kinds having direct hazardous effect such as carbon monoxide, hydrocarbons, and nitrogen oxides while others are secondary pollutants such as ozone, which undergoes a

series of reactions in the atmosphere and become hazardous to health [4]. The emissions exhausted into the surroundings pollute the atmosphere and cause global warming, acid rain, smog, odours and respiratory and other health hazards.

The urgent need for alternative fuel is essential to replace the supplement conventional fuels. The root causes for these emissions are non-stoichiometric combustion, dissociation of nitrogen and impurities in the fuel and air.

The major exhaust emissions HC, CO, NOx, SO_2, solid particles and the performance is increased by adding the suitable additives to the fuel reduced with the present technology. Additives are integral part of today's fuel. Together with carefully formulated base fuel composition they contribute to efficiency and long life. They are chemicals, which are added in small quantities either to enhance fuel performance, or to correct a deficiency as desired by the current legislation.

The effect of using ethanol-gasoline blends was studied by various researchers [5,6,7]. They used maximum of 15% of ethanol in ATd 34 engine. Palmer [8] has conducted a test on gasoline engine containing oxygenates. The effect of oxygenate in gasoline on exhaust emission and performance in a single cylinder, four stroke SI engine was studied. Ethanol can be produced form Azeotropic Solution by Pressure Swing Adsorption was studied by Pruksathorn and Vitidsant [9]. The effect of compressed natural Gas on performance and Emission in an Internal Combustion engine was studied by Semin and Kaleemuddin and Rao [10,11]. An experimental study is carried out by Shehata.M.S[12] to investigate engine performance parameters and methods of reducing emissions from spark ignition engine. The used engine is four stroke four cylinder naturally aspirated spark ignition engine with compression ratio of 9, bore diameter of 80 mm and stroke of 90 mm. The engine performance parameters are presented with and without exhaust gases recirculation (EGR).

Not much research has been done to study the performance, combustion and emission analysis of SI engine with alternate fuels. Hence the objective of this study is to investigate the use of plastic petrol fuel derived from waste plastic as an alternate fuel for the analysis of performance, combustion and emissions without any modifications in the basic SI engine and without adding any additives in comparison with Gasoline fuel.

This work examines the interactions resulting from the application of plastic petrol derived from plastic waste on a practical heavy-duty petrol engine system, with the aim of understanding their impact on emissions and performance. The goal of this experimental study is to assess the new fuel contributions to potential performance and efficiency penalties. Plastic petrol itself is a waste by product known to reduce the serious pollution threat to all most all the nation's worldwide [13.An attempt is made to assess the combustion and performance phenomenon of plastic petrol fuel. Some tests were conducted with the neat petrol application to verify the delineation line to fix up the performance of the petrol engine designed for petrol fuel. Marginal changes in the performance in the wise of SFC and BSFC cannot decipher the nature of combustion exactly [14,15].That is the reason why an extensive investigation encompassing the performance, emissions is taken up to evaluate the engine under the new conditions of the fuel implementation The merits and the demerits of the plastic petrol fuel implementation with the neat petrol application are discussed. The fuel in the form of liquid hydrocarbons derived from plastic waste constitutes approximately 80% of total post consumer plastic waste in India and includes PET, LDPE, PVC, HDPE, PP, PS etc. into liquid fuel oil [16].The process adopted is based on random de-polymerization of waste plastics in presence of a catalyst into liquid fuel [17].Fractional distillation was carried out by the author at his laboratory to convert the liquid hydro carbons to plastic petrol fuel at a temperature from 60^0 c to 160^0 c as suggested by the inventor and pale color petrol like fuel is derived by distillation with an approximate yielding of 30%. The distillation set up and the derived fuel is shown in the "Figure1".

Figure 1, Experimental setup of fractional distillation to extract plastic petrol from liquid hydrocarbons

2. Methodology

Hereafter, some of the current research pertaining to slope stabilizing piles undertaken by some researchers are discussed, taking into consideration the aspects of the newly adopted techniques available in the field at present namely the hybrid method of analysis, uncoupled method of analysis and also the coupled method of analysis.

2.1 Experimental set up

The engine used for the experiment is a four stroke single cylinder, air cooled petrol engine. The Petrol engine is a Greaves make. It is an air vertical engine developing about 3 B.H.P at 3000 rpm. The engine is rope started. The engine is coupled to a mechanical brake to absorb the power produced. The consumption of fuel is measured by means of the burette and a stop watch. A

three way cock regulates the flow of petrol from the tank of the engine. The figure 3 and 4 shows the set up of the engine. The specification of the S.I.engine is given in Table 1. The Figure 6 shows the image of blending plastic petrol and gasoline. Exhaust gas analysis of different components of exhaust gas are measured and compared and engine performance is analyzed for the parameters with the implementation of Gasoline and plastic petrol and blends of Plastic petrol with gasoline.

Table 1 : Specification of the SI Engine

Make	: Greaves (Enfield)
Bore	: 70 mm
Stroke	: 66.7 mm
Capacity	: 256 cc
RPM	: 3000 rpm
BHP	: 3.0 HP

2.2 INDUS (Exhaust Gas Analyzer)

The gas analyzer used is a INDUS make, which is capable of measuring 4 gases i.e. HC, CO, CO_2, O_2. A probe is attached to the back panel gas analyzer. The probe is placed in the exhaust pipe of the engine to analyze the emissions while running. The Figure2 shows the gas analyzer used in the experimentation.

Figure 2, Emission Analyzer

Figure 3, Greaves makes S.I Engine

Figure 4, Experimentation Set Up

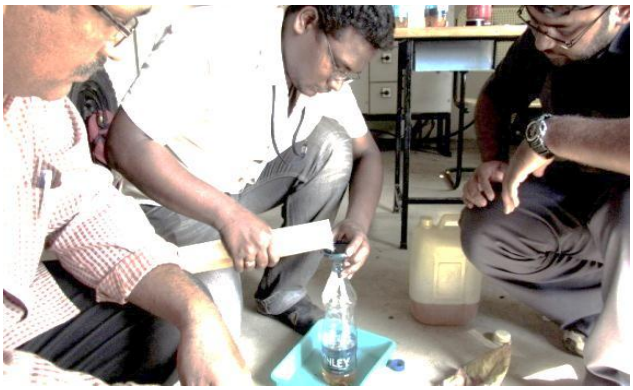

Figure 5, Blending of Plastic Petrol with Gasoline (50%+50%)

3. Results and Analysis

By using the formulas, performance characteristics are found at different loads for Gasoline, plastic petrol and blend (50%-50%) and the performance graphs are drawn. Figure 6 is the efficiency Vs BP graph. From the graph, it is observed that the efficiency goes on increasing as the load is increasing for gasoline, plastic petrol as well as for the blend.

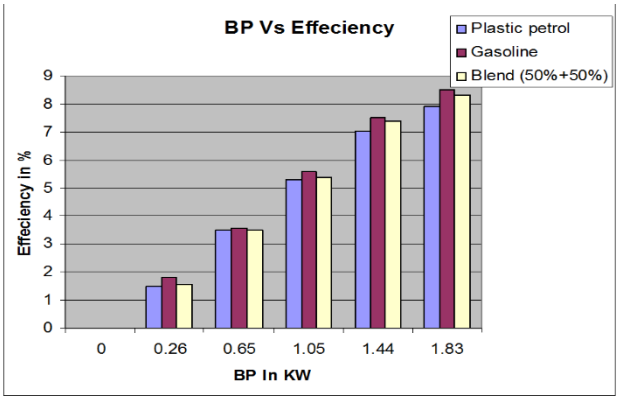

Figure 6, Efficiency Vs BP graph.

Figure 7 is the graph between the emissions of CO (in %) and the load for gasoline, plastic petrol and the blend for different loads. It is observed from the graph that the

emissions of CO are going on decreasing with the increase in load.

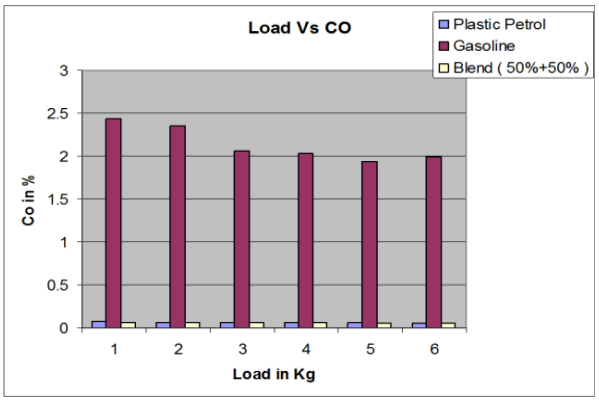

Figure7, CO in % Vs Load

Figure 8 is the graph between the emissions of CO_2 (in %) and the load for gasoline, plastic petrol and the blend for different loads. It is observed that the emissions of CO are going on increasing with the increase in load.

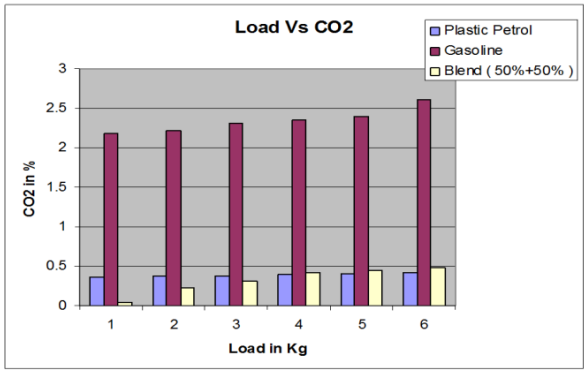

Figure8, CO_2 in % Vs Load

Figure 9 is the graph between the emissions of HC (in ppm) and the load for gasoline, plastic petrol and the blend for different loads. It is observed from the graph that the emissions of HC are going on decreasing with the increase in load.

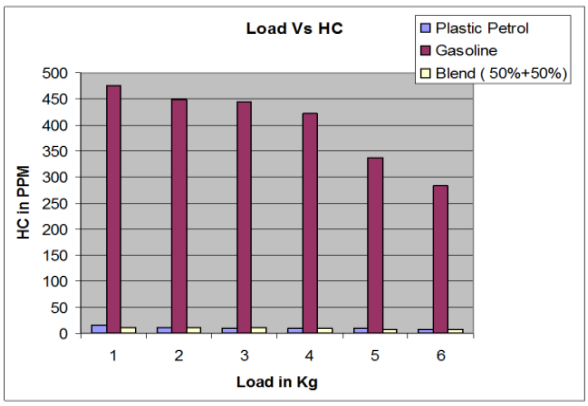

Figure9, HC in ppm Vs Load

Figure 10 is the graph between the emissions of O_2 (in %) and the load for gasoline, plastic petrol and the blend for different loads. It is observed from the graph that the emissions of O_2 are going on decreasing with the increase in load.

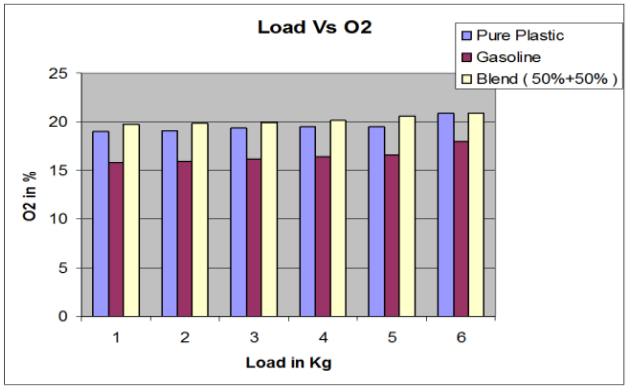

Figure 10, O_2 in % Vs load

It is observed that the efficiency is going on increasing with the increase in load. This may be due to the reason of low HC emissions which indicate the better combustion and thus the increase in efficiency. The flash point of the plastic petrol is more than the gasoline and thus the volatile nature of the plastic petrol is more when compared with the gasoline.

4. Conclusions

Plastic Petrol as substitute to Gasoline has been effectively used in existing S.I Engine without any modifications. Performance parameters like Break Thermal Efficiency and Specific Fuel Consumption has been recorded with the use of Plastic Petrol and compared with that of the gasoline and found to be on par with gasoline. Emission study has been carried out by measuring CO, HC and CO2 and compared against the emissions of gasoline at the similar working conditions. Harmful emissions like CO were observed to be low that gasoline at almost all working conditions. Unburnt HC and CO_2 is observed to be little higher with the use of plastic petrol than the gasoline. Total study reveals that the plastic petrol shall be conveniently used as substitute to gasoline without any engine modifications.

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